United States
Department of
Agriculture

Economic
Research
Service

Agricultural
Economic
Report
Number 683

Factor Intensity and the Changing Commodity Composition of U.S. Agricultural Trade

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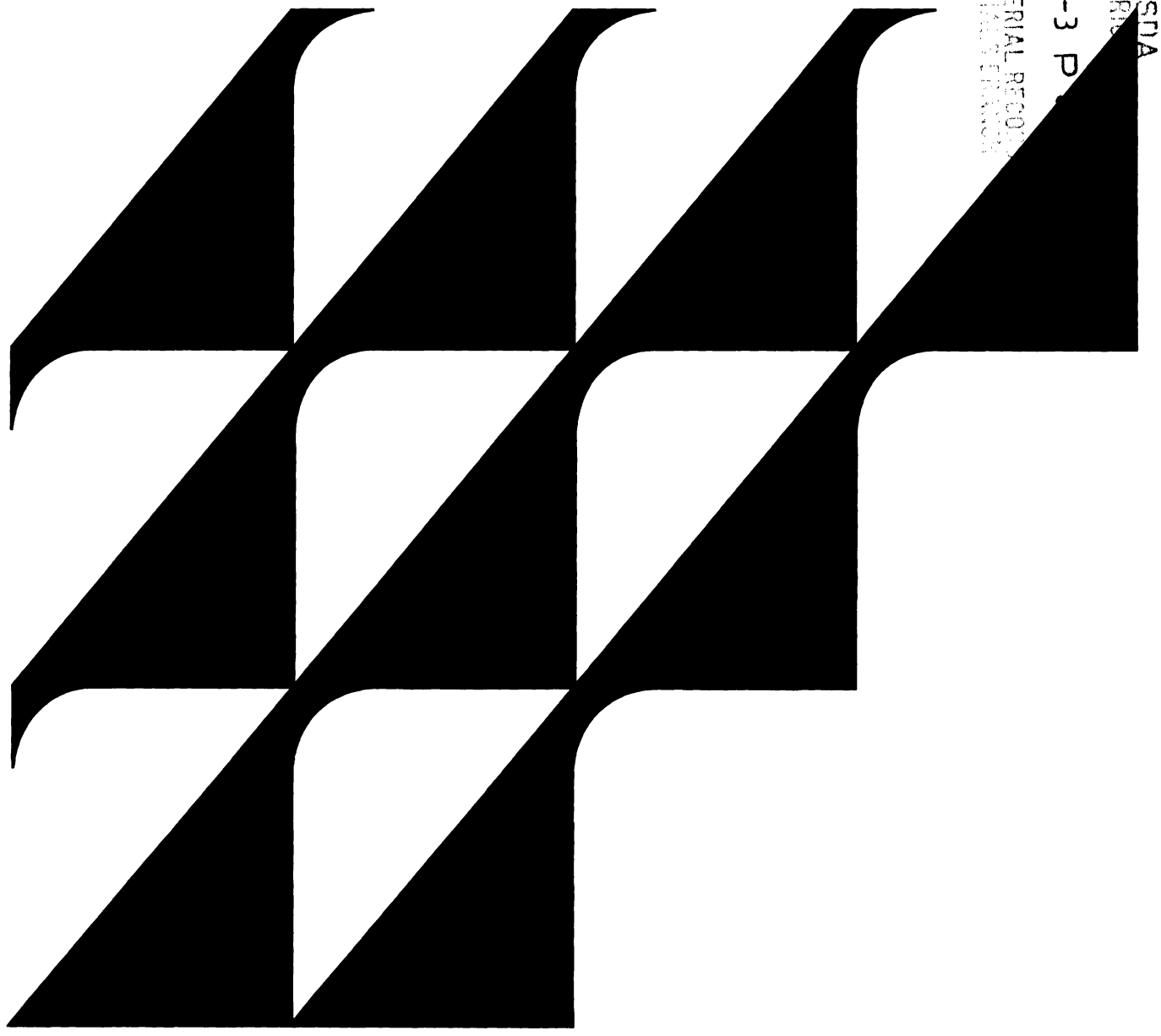

Factor Intensity and the Changing Commodity Composition of U.S. Agricultural Trade. By Chinkook Lee and Michelle Robinson. Agriculture and Rural Economy Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 683.

Abstract

This report uses the 1977 and the recently released 1982 national Input-Output (I/O) accounts of the U.S. economy to examine factor intensities and associated patterns of U.S. agricultural trade. U.S. agricultural exports were found to be more land-intensive than U.S. agricultural imports. However, the commodity composition of these exports tends to change as the income of importing countries changes. Furthermore, the more similar the countries that import from the United States are, in terms of economic factors, and the higher their incomes, the greater the likelihood of intra-industry, or two-way, trade in high-value commodities such as meat products and fruits and vegetables.

Keywords: Input-output, factor intensity, intra-industry trade.

Acknowledgments

The authors wish to express their appreciation to Thomas Hady and Gerald Schluter for editorial assistance, to William Edmondson and Kenneth Hanson for their technical assistance, and to Linda Felton and Pat Saunders for their word processing in preparing this manuscript.

1301 New York Avenue, NW. May 1994

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Summary

The commodity composition of U.S. agricultural exports has changed since the 1970's. In 1977, grains and oil crops were more than half of U.S. agricultural exports. By 1990, grains and oil crops had fallen to more than a third of U.S. agricultural exports, and high-value products, such as meat and other processed products, had doubled their 1977 export volume to total about a quarter of the exported agricultural commodities. The commodity composition of U.S. agricultural exports has changed because production technology for U.S. high-value commodities has become highly mechanized, which allows greater use of the United States' abundant farmland and requires little use of labor. These factors combine to make U.S. agricultural exports highly competitive with those from other nations.

This report examines the amount of U.S. land, labor, and capital devoted to the production of agricultural exports and the associated patterns of U.S. agricultural trade. The composition of U.S. exports reflects the purchasing patterns of different nations. Over time, these patterns change as nations alter their purchases in response to changes in income, relative prices, and domestic shortages. Perhaps the most important of these factors are changes in income that result from the development process. As a nation develops, its agricultural imports tend to shift away from food grains and industrial raw materials toward high-value commodities, such as meat products and fruits and vegetables.

As developing nations earn higher incomes and become increasingly self-sufficient in food production, the composition of U.S. agricultural exports will likely shift toward high-value products, such as meats, fruits and vegetables, and other processed foods. However, products importing countries use to produce high-value commodities, for example, feed grains and oil crops (used to produce livestock), will likely also remain a major share of U.S. agricultural exports. As the commodity composition of agricultural exports changes, the use of land and labor for producing agricultural exports will also change, because different commodities have different direct and economywide land and labor requirements.

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Introduction

Foreign trade provides a nation with an alternative market for goods and services from its abundant factors of production. Agricultural trade already plays an important role in the U.S. economy. Net U.S. agricultural exports have been positive since 1959 and, to some degree, have offset the trade deficit for nonagricultural products. Each million dollars of agricultural exports require (directly and indirectly) significant amounts of land, labor, and capital. The amount of U.S. land, labor, and capital devoted to the production of agricultural exports has varied during the 1980's. This is the result of the fluctuating commodity composition of U.S. trade patterns in response to changes in importing countries' income levels or development patterns.

This paper has three objectives. First, we use the well-known trade theory of relative factor endowments to examine factor intensities and associated patterns of U.S. agricultural trade. To do so, we use the 1977 and the recently released 1982 national Input-Output (I/O) accounts of the U.S. economy to create an I/O model for estimating the land and labor used to produce U.S. agricultural exports and imports in 1977, 1982, and 1990. An I/O model traces the production flows required to produce output for purchase by consumers, government, businesses, and foreign buyers. The usefulness of such a model lies in its ability to account for the production of goods and services generated both directly, in the sector producing the output, and indirectly, through additional business activity generated to meet the final demands of buyers.

Second, we examine how changes in the income levels of purchasing countries influence the commodity composition of U.S. agricultural exports. To do so, we examine U.S. agricultural trade with selected countries that are either developing, middle income, or developed. Finally, we explore the implications of intra- versus inter-industry trade.

Theoretical Considerations

The Heckscher-Ohlin (H-O) theory of international trade identifies the difference in relative factor endowments among nations as the basic cause or determinant of comparative advantage and, therefore, international trade. This dominant theory of trade is quite straightforward. Under the H-O theory, a nation will export the commodities that require the intensive use of its relatively abundant and cheap factor, and import the commodities that require the intensive use of its relatively scarce and more expensive factor.

An empirical test of the H-O theory by Leontief, who used the Input-Output tables of the U.S. Economy, revealed that, despite relative capital abundance and labor scarcity, the capital-to-labor ratio of U.S. imports was greater than that of U.S. exports. This phenomenon has been called the Leontief Paradox. This study finds that U.S. agricultural trade is consistent with the H-O theory. The Leontief Paradox does not occur in present-day agricultural trade.

By itself, however, the dominant theory of international trade cannot explain intra-industry, or two-way, trade. Why do countries with similar factor endowments engage in trade? Why does a nation both import and export a certain type of commodity? Yet, these trade patterns exist and represent major portions of trade flows.

Further developments in trade theory have attempted to address these issues. For example, the role of demand hypothesis notes that nations with similar per

capita incomes consume similar bundles of goods. Formal models by Krugman [5][1] and others try to derive this trade pattern as a result of scale economies, imperfect competition, and product differentiation. Markusen [7] has combined several of these interpretations in explaining that the closer the countries are in terms of factor endowment and the higher their incomes, the greater the likelihood of intra-industry trade. On this premise, intra-industry trade should occur between developed countries (East-West) while inter-industry trade should occur between North-South countries, the North being more capital abundant and the South more labor abundant. Balassa and Bauwens [1] found that intra-industry trade is positively correlated with income. McCorriston and Sheldon [8] analyzed trade for the United States and the European Community (EC) in processed agricultural products to other developed countries and found that the EC exhibited more intra-industry trade than the United States.

Trade in agricultural goods is primarily in food and feed products. Among agricultural commodities, income elasticities are lowest for roots and tubers, higher for coarse grains (such as corn) for human consumption, and higher still for fruits, vegetables, and animal products. At low-income levels, a country is likely to spend a large share of its income on direct consumption of grains, such as wheat, rice, and corn. A priori, a low-income country would have higher income elasticities for food grains than would higher income nations. In contrast, high-income countries spend a small share of their food budget on direct grain consumption and have low-income elasticities for these goods. Elasticities for meat and animal products are higher (though still less than one), which indirectly causes feed grains and oil crops used for animal feed to have higher income elasticities as well. The net result of these income elasticities is that, over time, the commodity composition of food consumption changes.

Most trade theory explains trade in terms of manufactured goods. Data limitations often preclude a blending of theoretical and empirical tests of the basis for international trade.[2] Sometimes, where the data exists, the theoretical edges must be rounded to fit the theory to the world revealed in the data. In this paper, we examine data on actual trade, both for generic support of theoretical foundations and the economic foundations of U.S. agricultural trade.

[1]Numbers in brackets refer to sources listed in the References section.

[2]The MIT Press devoted an entire volume (2) to this point.

Targeting agricultural trade makes investigating land endowments and land intensity a natural departure from the usual analysis of labor and capital endowments. And because land is more location-specific than labor or capital, spatial considerations complicate the efficient transmission of market signals.

The Commodity Composition of U.S. Agricultural Exports

In 1990, the United States exported $39.3 billion worth of agricultural products. The commodity composition of agricultural exports has changed significantly since 1977. In 1977, food grains, feed grains, and oil crops made up the bulk of U.S. agricultural exports, accounting for nearly 53 percent of total exports. Feed grains represented the largest share (21 percent). By 1982, these three groups still constituted the majority of agricultural exports, rising slightly to 55 percent of the total. However, oil crops displaced feed grains as the commodity group holding the largest share (19 percent).

By 1990, the picture had changed. High-value products significantly contributed to total agricultural exports, displacing both food grains and oil crops. Feed grains still represented the largest share of exports (18 percent), but meat products and other processed foods represented another 12 percent each.

Japan and Western Europe have continued to be the major consumers of U.S. agricultural commodities, importing 52 percent of total agricultural exports in 1977, 46 percent in 1982, and 39 percent in 1990. Canada more than doubled its share of U.S. exports, from 5 percent in 1982 to 11 percent in 1990. This increase was partially due to a surge in Canadian demand for high-value U.S. products, such as vegetables, fruits, nuts, and other processed foods.

Thus, the changing commodity composition of U.S. agricultural exports reflects the changing import demands of various countries. As countries' income levels continue to increase, agricultural exports from the United States may continue to shift from food grains toward feed crops and high-value products, such as fruits, vegetables, and processed foods.

Factor Intensity of U.S. Agricultural Trade

We define factor intensity as the ratio of factor (land, labor, or capital) use per million dollars of exports in

current-year prices. Factor intensity does not depend on the total value of exports for a given year or region, but reflects the composition of agricultural exports in each year. Because different commodities require different combinations of labor and land, factor intensity varies as the composition of exports changes. In general, food grains, feed grains, and oil crops have low labor intensities and high land intensities. High-value products, such as fruits, vegetables, and nuts, have higher labor intensities and much lower land intensities. Because of these differences in production requirements, changes in the commodity mix of exports from year to year influence the factor intensity of agricultural exports.

Table 1 shows U.S. agricultural exports to major purchasers by commodity group for 1977, 1982, and 1990. The table is based on trade information [9, 15] and is reproduced here with some revisions and updates for 1990. In general, the value of U.S. agricultural exports increased over these years, with strong gains in vegetables, fruits, and nuts, and meat products (high-value commodities). However, there were substantial drops in food grain and oil crop exports from 1982 to 1990. Exports of vegetables, fruits, and nuts increased from $975 million in 1977 to more than $1 billion in 1982 and $3 billion in 1990. Meanwhile, exports of food grains and oil crops decreased from $6.7 and $6.8 billion in 1982 to $4 and $3.9 billion in 1990.

Western Europe and Japan have remained major customers for U.S. agricultural exports, with Western Europe obtaining 35 percent in 1977 and 31 percent in 1982, and Japan garnering 16 percent in 1977 and 15 percent in 1982 (table 1). Japan edged out Western Europe's near 19 percent of total U.S. agricultural exports in 1990 with roughly 21 percent. Likewise, Canada increased its 5 percent share in 1982 to 11 percent in 1990. And, as discussed earlier, there has been a clear shift, especially from 1982 to 1990, from food grains and oil crops to high-value commodity groups such as vegetables, fruits, and nuts, meat products, and other processed foods.

Table 2 shows current and constant dollar values and shares of U.S. agricultural exports in 1977, 1982, and 1990. The table reveals that shares of food grains, feed grains, and oil crops decreased in 1990 from 1977 levels, while shares of meat products and other processed foods increased. Although feed grains' share of U.S. agricultural exports has declined over time, feed grains remained the largest commodity group in the mix of agricultural exports in 1990.

Of every $1 million in exports in 1990, feed grains accounted for $183,194, or 18.3 percent (table 3). Meat products, with $122,007, had the second-largest share (12.2 percent), closely followed by other processed foods, with $121,568 (nearly 12.2 percent). Despite falling from around a 70-percent share in both 1977 and 1982 to a 60-percent share in 1990, bulk farm products represented the major component of total agricultural exports with $600,925 for every $1 million in 1990.

Tables 4, 5, and 6 show estimates of land and labor used to produce U.S. agricultural exports in 1977, 1982, and 1990. These estimates are updated from a previous study [6] and confirm the relationship between factor endowments and the commodity composition of agricultural trade predicted by theory. Theory suggests that land-to-labor ratios for exports to land-scarce Japan, South Korea, and Western Europe should be relatively high, and they were around 100 harvested acres per worker in 1977 and 1982. But, these ratios fell in the 1980's, indicating that these nations imported less land-intensive agricultural products in 1990 than they did in both 1977 and 1982.

The former USSR and African countries, however, show land-to-labor ratios of more than 100 in 1977, 1982, and 1990. These countries had high land-to-labor ratios because they import relatively more food and feed grains from the United States. In contrast, this ratio for exports to land-abundant Canada remained under 35 harvested acres per worker in 1977 and was under 30 in 1990.

The United States imported nearly $10 billion worth of competitive agricultural products in 1982 (table 7). This activity nearly doubled by 1990 to $17.2 billion. In 1990, most of these competitive imports were from developed nations. However, the United States imported a substantial amount of vegetables, fruits, and nuts from developing countries in 1990.

Using the same calculation method as for exports, we estimated the implied factor content of imports assuming they used U.S. production technology. Given the relative abundance of land in the United States, the commodity composition of 1982 U.S. agricultural imports coincides with what is expected from factor endowment theory, with an overall land-to-labor ratio of 23.5 (table 8). Likewise, in 1990, the land-to-labor ratio for agricultural imports was 30.1 (table 8), strikingly similar to the factor intensity of U.S. agricultural exports to Canada of nearly 30 (table 6).

Table 1--U.S. agricultural exports, by destination, 1977-90, selected years

Commodity	World			Canada			Mexico			Western Europe		
	1977	1982	1990	1977	1982	1990	1977	1982	1990	1977	1982	1990
						1,000 dollars						
Livestock	209,526	439,696	650,049	39,522	45,414	98,851	21,563	53,014	85,747	46,273	197,567	85,037
Food grains	2,732,232	6,698,159	4,044,360	1,182	1,026	670	41,252	72,624	51,750	210,869	552,282	115,927
Feed grains	4,912,549	6,487,406	7,204,420	36,339	44,220	102,955	247,828	204,481	777,153	2,072,751	1,826,558	444,229
Cotton	1,534,787	1,965,018	2,795,479	69,079	56,815	62,376	160	330	53,655	222,303	265,407	475,223
Vegetables, fruits, and nuts	975,599	1,744,838	3,006,452	376,146	536,589	1,170,133	13,102	107,984	166,941	250,552	392,796	675,351
Oil crops	4,791,941	6,802,370	3,862,683	149,549	116,315	122,918	115,699	270,873	222,595	2,751,069	4,137,652	1,645,946
Tobacco	1,094,283	1,546,541	1,441,116	3,677	8,898	2,939	0	8	53	480,591	754,477	714,833
Meat products	1,514,582	2,138,167	4,798,127	211,343	136,651	574,093	71,991	142,203	415,853	368,739	346,728	201,362
Feeds and flours	1,560,210	2,345,206	3,237,335	96,219	138,715	355,957	8,668	21,421	130,045	492,078	867,529	1,222,401
Vegetable fats and oils	2,334,085	2,998,347	2,128,793	122,101	108,608	180,669	92,936	121,710	146,431	813,988	1,189,371	215,545
Other processed foods	1,407,275	2,526,209	4,780,877	318,929	454,466	1,135,690	29,871	90,844	334,720	385,038	548,392	835,431
Other agricultural products	569,087	930,642	1,376,976	110,389	172,155	326,986	21,333	70,788	115,842	264,217	384,659	485,576
Total agricultural exports	23,636,156	36,622,599	39,326,667	1,534,475	1,819,872	4,197,415	664,403	1,156,280	2,553,616	8,358,468	11,463,418	7,319,652

	Japan			South Korea			USSR			Africa		
	1977	1982	1990	1977	1982	1990	1977	1982	1990	1977	1982	1990
						1,000 dollars						
Livestock	24,700	35,120	74,332	8,211	11,129	5,039	272	0	2,151	1,252	6,674	6,843
Food grains	374,516	563,681	420,230	202,224	300,153	216,260	427,897	802,182	542,547	396,338	877,044	615,851
Feed grains	1,065,621	1,515,787	1,984,986	158,475	378,716	603,691	387,642	834,626	1,101,681	118,662	273,678	448,730
Cotton	310,069	502,468	580,723	315,251	425,507	480,779	453	67	1,277	65,105	17,586	155,940
Vegetables, fruits, and nuts	123,825	247,374	470,516	128	1,468	17,734	13,349	7,680	11,951	19,796	31,121	41,288
Oil crops	964,673	1,003,987	844,509	44,280	142,255	196,226	159,031	171,265	61,422	36,359	40,956	8,909
Tobacco	259,953	309,920	303,314	21,159	4,183	13,689	0	1,262	0	96,375	76,890	13,154
Meat products	396,908	773,927	2,035,745	108,125	170,575	904,371	7,611	5,061	98,761	22,130	36,971	28,781
Feeds and flours	64,615	88,304	312,937	11,929	68,074	19,375	24,114	1	3,732	252,551	479,829	252,894
Vegetable fats and oils	130,002	111,899	80,570	40,116	50,488	54,546	1,599	40,571	361,938	262,829	281,559	257,949
Other processed foods	113,076	336,336	771,569	5,811	17,979	89,458	4,656	6,791	78,006	75,872	96,375	66,107
Other agricultural products	28,831	66,210	130,952	3,576	10,833	41,614	9,959	1,768	4,225	15,017	19,092	17,384
Total agricultural exports	3,856,789	5,555,013	8,057,708	919,285	1,581,360	2,643,506	1,036,583	1,871,274	2,267,690	1,362,286	2,237,775	1,934,658

Source: [9].

Table 2--Current and constant value of U.S. agricultural exports, 1977-90, selected years

Commodity	Current value			Share of agricultural exports		
	1977	1982	1990	1977	1982	1990
	1,000 dollars			Percent		
Livestock	209,526	439,696	650,049	0.9	1.2	1.7
Food grains	2,732,232	6,698,159	4,044,360	11.6	18.3	10.3
Feed grains	4,912,549	6,487,406	7,204,420	20.8	17.7	18.3
Cotton	1,534,787	1,965,018	2,795,479	6.5	5.4	7.1
Vegetables, fruits, and nuts	975,599	1,744,838	3,006,452	4.1	4.8	7.6
Oil crops	4,791,941	6,802,370	3,862,683	20.3	18.6	9.8
Tobacco	1,094,283	1,546,541	1,441,116	4.6	4.2	3.7
Meat products	1,514,582	2,138,167	4,798,127	6.4	5.8	12.2
Feeds and flours	1,560,210	2,345,206	3,237,335	6.6	6.4	8.2
Vegetable fats and oils	2,334,085	2,998,347	2,128,793	9.9	8.2	5.4
Other processed foods	1,407,275	2,526,209	4,780,877	6.0	6.9	12.2
Other agricultural products	569,087	930,642	1,376,976	2.4	2.5	3.5
Total agricultural exports	23,636,156	36,622,599	39,326,667	100.0	100.0	100.0

	Constant value			Share of agricultural exports		
	1977	1982	1990	1977	1982	1990
	1,000 dollars			Percent		
Livestock	298,424	439,696	515,126	1.1	1.2	1.5
Food grains	3,989,059	6,698,159	4,657,248	14.1	18.3	13.5
Feed grains	5,895,059	6,487,406	6,818,758	20.8	17.7	19.7
Cotton	1,412,004	1,965,018	2,331,806	5.0	5.4	6.8
Vegetables, fruits, and nuts	1,539,482	1,744,838	2,671,025	5.4	4.8	7.7
Oil crops	4,216,908	6,802,370	3,545,839	14.8	18.6	10.3
Tobacco	1,968,135	1,546,541	631,468	7.0	4.2	1.8
Meat products	2,074,770	2,138,167	3,995,894	7.3	5.8	11.6
Feeds and flours	1,850,783	2,345,206	2,617,895	6.5	6.4	7.6
Vegetable fats and oils	2,352,908	2,998,347	1,880,913	8.3	8.2	5.4
Other processed foods	2,005,833	2,526,209	3,697,152	7.1	6.9	10.7
Other agricultural products	706,997	930,642	1,178,707	2.5	2.5	3.4
Total agricultural exports	28,310,362	36,622,599	34,541,831	100.0	100.0	100.0

Source: [9].

Table 3--U.S. agricultural exports, 1990: Actual value and commodity composition for $1 million in exports

Commodity	Actual value	Composition of $1 million in exports	Share of total
	1,000 dollars	Dollars	Percent
Livestock	650,049	16,529	1.7
Food grains	4,044,360	102,840	10.3
Feed grains	7,204,420	183,194	18.3
Cotton	2,795,479	71,084	7.1
Vegetables, fruits, and nuts	3,006,452	76,448	7.6
Oil crops	3,862,683	98,220	9.8
Tobacco	1,441,116	36,645	3.7
Other crops	627,825	15,964	1.6
Bulk farm products	23,632,384	600,925	60.1
Meat products	4,798,127	122,007	12.2
Feeds and flours	3,237,335	82,319	8.2
Vegetable fats and oils	2,128,793	54,131	5.4
Processed farm products	10,164,255	258,457	25.8
Total agriculture	33,796,639	859,382	85.9
Other processed foods	4,780,877	121,568	12.2
Other agricultural products	749,151	19,049	1.9
Total agricultural exports	39,326,667	1,000,000	100.0

Source: [9].

Table 4--Factors used to produce U.S. agricultural exports, by destination, 1977

Commodity	World		Canada		Mexico		Western Europe	
	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres
	Number							
Livestock	13,497	541,215	2,594	81,314	1,046	44,166	3,258	103,547
Food grains	126,191	28,947,020	40	13,370	1,409	466,622	3,258	2,385,247
Feed grains	197,727	30,242,048	855	187,630	5,829	1,279,613	48,756	10,702,256
Cotton	67,195	4,362,965	2,163	197,997	5	459	6,960	637,172
Vegetables, fruits, and nuts	64,316	787,582	15,219	234,519	534	8,760	11,414	205,139
Oil crops	122,722	22,504,891	2,319	604,926	1,794	468,003	42,655	11,128,083
Tobacco	39,438	127,054	159	453	0	0	20,765	59,272
Meat products	78,772	2,943,985	21,788	728,179	7,422	248,044	38,015	1,270,484
Feeds and flours	58,065	4,287,406	4,259	363,283	342	26,909	21,291	1,790,029
Vegetable fats and oils	79,114	5,779,622	4,332	318,690	3,298	242,568	28,882	2,124,552
Other processed foods	59,831	806,824	22,830	284,784	2,150	42,464	27,844	348,543
Other agricultural products	25,490	250,929	14,397	33,386	4,907	18,235	54,873	69,609
Total agricultural export	932,358	101,581,541	90,956	3,048,530	28,734	2,845,842	311,915	30,823,932
Land-to-labor ratio	109.0	NA	33.5	NA	99.0	NA	98.8	NA

	Japan		South Korea		USSR		Africa	
	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres
	Number							
Livestock	1,562	52,444	338	17,079	11	564	60	2,239
Food grains	12,791	4,236,341	6,907	2,287,459	14,614	4,840,161	13,356	4,483,181
Feed grains	25,066	5,502,131	3,728	818,256	9,118	2,001,516	2,791	612,689
Cotton	9,708	888,730	9,870	903,583	14	1,298	2,038	186,606
Vegetables, fruits, and nuts	6,153	80,655	6	88	678	12,449	584	13,683
Oil crops	14,957	3,902,105	687	179,113	2,466	643,281	564	147,072
Tobacco	11,232	32,060	914	2,610	0	0	4,164	11,886
Meat products	40,919	1,367,540	11,147	372,543	785	26,224	2,281	76,249
Feeds and flours	2,229	156,395	553	48,506	1,128	99,452	11,776	1,036,368
Vegetable fats and oils	4,613	339,312	1,423	104,705	57	4,173	9,326	685,998
Other processed foods	8,418	107,655	385	5,125	253	3,597	5,727	123,020
Other agricultural products	25,529	23,005	6,508	3,172	8,652	14,184	8,526	9,349
Total agricultural export	163,177	16,688,373	42,466	4,742,237	37,776	7,646,900	61,374	7,388,340
Land-to-labor ratio	101.8	NA	111.7	NA	202.4	NA	120.4	NA

NA - Not applicable.
Sources: [11, 14]

Table 5--Factors used to produce U.S. agricultural exports, by destination, 1982

Commodity	World		Canada		Mexico		Western Europe	
	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres
	Number							
Livestock	29,420	870,036	2,268	72,259	3,065	107,175	16,278	476,217
Food grains	123,274	37,881,743	19	5,803	1,337	410,728	10,164	3,123,456
Feed grains	103,335	20,376,689	704	138,893	3,257	642,267	29,094	5,737,147
Cotton	55,089	4,822,833	1,593	139,444	9	810	7,441	651,400
Vegetables, fruits, and nuts	61,984	966,624	17,489	256,988	2,605	58,532	15,363	292,691
Oil crops	123,899	34,141,529	2,119	583,792	4,934	1,359,529	75,364	20,767,139
Tobacco	27,614	86,974	159	500	0	0	13,471	42,430
Meat products	70,670	2,686,071	4,517	171,668	4,700	178,642	11,460	435,577
Feeds and flours	50,077	3,625,593	3,078	214,328	485	33,087	18,448	1,341,243
Vegetable fats and oils	73,144	7,263,471	2,649	263,102	2,969	294,841	29,015	2,881,241
Other processed foods	61,537	1,006,125	10,726	121,842	2,481	73,731	13,271	174,113
Other agricultural products	239,138	451,114	15,453	41,999	8,557	47,337	68,018	142,833
Total agricultural export	1,019,180	114,178,802	61,133	2,010,618	34,398	3,206,681	307,386	36,065,488
Land-to-labor ratio	112.0	NA	32.9	NA	93.2	NA	117.3	NA

	Japan		South Korea		USSR		Africa	
	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres
	Number							
Livestock	1,971	57,046	430	22,955	0	0	412	12,858
Food grains	10,374	3,187,924	5,524	1,697,529	14,763	4,536,777	16,141	4,960,162
Feed grains	24,144	4,761,028	6,032	1,189,532	13,294	2,621,528	4,359	859,612
Cotton	14,087	1,233,230	11,929	1,044,341	2	164	493	43,162
Vegetables, fruits, and nuts	9,952	117,231	53	1,009	380	8,153	782	17,765
Oil crops	18,287	5,039,075	2,591	713,987	3,119	859,590	746	205,561
Tobacco	5,534	17,429	75	235	23	71	1,373	4,324
Meat products	25,580	972,245	5,638	214,285	167	6,358	1,222	46,445
Feeds and flours	2,340	136,047	1,404	105,291	0	2	9,882	742,171
Vegetable fats and oils	2,730	271,074	1,232	122,307	990	98,283	6,869	682,074
Other processed foods	8,210	104,152	439	5,400	149	1,530	2,460	66,751
Other agricultural products	35,961	59,710	10,229	10,483	15,567	13,702	13,837	19,864
Total agricultural exports	159,169	15,956,190	45,576	5,127,353	48,455	8,146,158	58,576	7,660,750
Land-to-labor ratio	100.2	NA	112.5	NA	168.1	NA	130.8	NA

NA - Not applicable.
Sources: [11, 14].

Table 6--Factors used to produce U.S. agricultural exports, by destination, 1990

Commodity	World		Canada		Mexico		Western Europe	
	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres
				Number				
Livestock	37,997	1,106,777	6,280	175,303	3,635	170,987	4,547	175,666
Food grains	88,352	27,150,242	12	3,789	952	292,674	2,134	655,630
Feed grains	111,957	22,076,878	1,640	323,378	12,379	2,441,007	7,076	1,395,306
Cotton	67,384	5,899,266	1,749	153,092	1,504	131,688	13,323	1,166,361
Vegetables, fruits, and nuts	101,477	1,604,831	38,850	562,657	4,683	92,412	28,333	8,261,108
Oil crops	66,573	18,344,739	2,239	616,933	4,054	1,117,219	29,979	8,261,108
Tobacco	11,622	36,606	52	165	1	3	12,763	40,201
Meat products	136,138	5,174,395	18,975	721,204	13,745	522,415	6,655	252,961
Feeds and flours	66,008	4,163,128	8,115	549,765	2,792	201,030	26,419	1,889,456
Vegetable fats and oils	47,297	4,696,786	4,407	437,669	3,572	354,728	5,258	522,156
Other processed foods	90,565	1,152,063	25,902	289,355	8,051	134,557	19,411	211,823
Other agricultural products	193,881	516,850	32,573	76,384	18,518	67,025	43,346	187,559
Total agricultural exports	1,019,252	91,922,561	140,795	3,909,694	73,886	5,525,745	199,245	15,296,882
Land-to-labor ratio	90.2	NA	27.8	NA	74.8	NA	76.8	NA

	Japan		South Korea		USSR		Africa	
	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres	Workers	Harvested acres
				Number				
Livestock	5,788	166,483	250	6,721	556	7,116	365	10,834
Food grains	7,734	2,376,630	3,980	1,223,068	9,985	3,068,399	11,334	3,482,973
Feed grains	31,618	6,234,764	9,616	1,896,170	17,536	3,457,969	7,148	1,409,443
Cotton	16,280	1,425,295	13,478	1,179,998	0	0	4,372	382,731
Vegetables, fruits, and nuts	18,936	238,852	784	12,857	577	12,360	1,025	24,043
Oil crops	15,382	4,238,645	3,574	984,871	1,112	306,544	162	44,715
Tobacco	5,416	17,058	244	770	0	0	235	740
Meat products	67,285	2,557,403	29,891	1,136,115	3,264	124,068	951	36,156
Feeds and flours	7,974	482,458	420	29,947	77	5,771	5,209	391,160
Vegetable fats and oils	1,965	195,180	1,331	132,137	8,861	879,885	6,293	624,879
Other processed foods	18,044	206,405	2,081	24,440	2,376	84,085	1,634	39,487
Other agricultural products	50,717	75,968	16,460	18,595	17,549	15,273	13,118	19,829
Total agricultural exports	247,140	18,215,140	82,109	6,645,689	61,893	7,961,470	51,846	6,466,990
Land-to-labor ratio	73.7	NA	80.9	NA	128.6	NA	124.7	NA

NA - Not applicable.
Sources: [11, 14]

Table 7--U.S. agricultural competitive imports, by type of economy, 1982 and 1990

Commodity	World		Developing		Developed		Centrally planned	
	1982	1990	1982	1990	1982	1990	1982	1990
	1,000 dollars							
Livestock	550,526	1,200,538	143,983	437,591	397,957	756,659	8,584	6,288
Food grains	7,057	84,230	225	259	6,807	83,964	26	7
Feed grains	95,631	136,080	14,212	23,161	79,049	110,033	2,368	2,886
Cotton	13,140	519	12,929	411	13	104	199	4
Vegetables, fruits, and nuts	962,799	2,205,419	816,990	1,847,988	142,071	342,407	3,738	15,024
Oil crops	61,496	151,705	33,318	59,744	27,174	84,600	1,004	7,361
Tobacco	503,737	1,165,728	370,119	896,839	98,455	186,322	35,163	82,567
Meat products	2,228,585	3,279,913	361,093	422,969	1,705,601	2,661,161	161,890	195,783
Feeds and flours	143,391	321,529	23,846	62,960	117,098	251,364	2,446	7,205
Vegetable fats and oils	395,492	768,176	312,387	351,029	81,505	415,160	1,598	1,987
Other processed foods	4,429,219	7,134,763	1,733,524	2,876,402	2,620,466	4,086,158	75,232	172,203
Other agricultural products	589,412	776,479	188,855	145,530	363,474	593,249	37,081	37,700
Total agricultural imports	9,980,484	17,225,079	4,011,481	7,124,883	5,639,671	9,571,181	329,329	529,015

Source: [9].

Table 8--Factors used to produce U.S. competitive agricultural imports, 1982 and 1990

Commodity	Workers		Harvested acreage	
	1982	1990	1982	1990
	Number			
Livestock	29,664	36,177	1,281,740	2,098,952
Food grains	254	1,664	78,047	485,174
Feed grains	931	1,935	183,432	387,377
Cotton	370	13	32,397	1,017
Vegetables, fruits, and nuts	22,341	58,049	392,175	1,049,907
Oil crops	444	2,395	122,465	657,479
Tobacco	6,106	8,164	19,233	29,055
Meat products	73,355	82,780	2,787,994	3,289,064
Feeds and flours	3,290	5,434	218,947	370,301
Vegetable fats and oils	7,087	15,022	703,976	1,546,239
Other processed foods	107,808	117,801	1,486,096	1,985,122
Other agricultural products	64,964	73,753	155,637	216,547
Total agricultural imports	316,614	403,185	7,462,141	12,116,234
Land-to-labor ratio	23.5	30.1	n/a	n/a

n/a = not available
Sources: [11, 14]

Income Elasticities and Agricultural Exports

Patterns of agricultural trade also reflect the different income levels of purchasing nations. Exports to Africa clearly display the tendency of developing nations to devote a large share of their food budget to food grains. Food grain imports by developing countries accounted for nearly 30 percent of total agricultural imports from the United States in 1977 and nearly 40 percent in 1982 and 1990.

Nations with income levels comparable to the United States' income levels tend to import large shares of fruits, vegetables, and meat products. Canada is a notable example; for the 3 years studied, about 40 percent of Canada's total imports from the United States consisted of these products. For high-income countries with small land endowments, feed grains and oil crops, used to support domestic livestock production, are also likely to make up large shares of their agricultural imports. These crops combined to represent 58 percent in 1977 and 52 percent in 1982 of U.S. agricultural exports to Western Europe.

These crops represented 53 percent in 1977 and 45 percent in 1982 of total agricultural exports to Japan. However, by 1990, these shares decreased to 12 percent for Western Europe and to 31 percent for Japan. The falling shares, particularly for soybeans, underscore some of the trade tensions existing between the United States and the EC.

We previously noted the tendency of low-income nations to spend a large share of income on food grains, the most land-intensive commodity group. Exports to Africa, for example, are the most land-intensive of the regions presented. However, deteriorating per capita incomes in African nations during the 1980's caused their agricultural imports to fall between 1982 and 1990. As income grows, imports of products that are less land-intensive, such as fruits and vegetables, meat products, and other processed foods, increase. Japan, for example, decreased its demand for oil crops substantially from 1982 to 1990, while increasing its demand for meat products, reflecting again that as income increased from 1982 to 1990, the demand for meat products increased.

The experience of South Korea demonstrates the effects of income elasticities on demand when a nation's income rises. As a share of South Korea's agricultural imports from the United States, food grains fell from nearly 22 percent in 1977 to only 8 percent in 1990. The meat products share increased, however, from nearly 12 percent in 1977 to 34 percent in 1990.

Intra-Industry Agricultural Trade

Table 9 shows intra-industry trade measures between the United States and selected countries during 1982 and 1990. The table supports at least three aspects of agricultural trade between the United States and other nations. First, with the exception of Africa, intra-industry trade has increased over time, as reflected in the Grubel-Lloyd measures, which are estimates used to gauge the level of intra-industry trade in a given industry.

Second, U.S. intra-industry trade tends to be higher with high-income countries, such as Canada and Western Europe. Third, for 1982 and 1990, intra-agricultural trade was higher for high-valued agricultural products, such as meat products, fruits and vegetables, and other processed foods, than for bulk farm products. Products that are among the least land-intensive, such as vegetables, fruits, and nuts, figure prominently in agricultural exports to Canada. For example, exports of these crops to Canada, the most land-abundant of the regions considered, were more than 20 percent of total agricultural exports to Canada. Thus, intra-industry trade is positively correlated with income.

Policy Implications

It is important to note that U.S. agricultural exports to developing nations, particularly countries in Africa and Korea in an earlier period (1977), were primarily farm products. On the other hand, U.S. imports from developing nations (more labor-abundant nations) were mainly vegetables, fruits, and nuts as well as processed foods. Thus, the factor endowment theory of comparative advantage seems to be the predominant influence on U.S. agricultural trade with these countries.

More than 50 percent of the value of U.S. agricultural exports went to developed countries--Canada, Western Europe, and Japan. There are two implications of this phenomenon. First, exports to these countries are mostly high-valued agricultural products, indicating that the income effects of the demand for U.S. agricultural products outweigh exports based on differing factor endowments. Second, U.S. agricultural trade with these countries consists of products that are very close substitutes for each other in terms of factor inputs and consumption. Thus, a considerable part of U.S. agricultural trade with these countries is intra-industry trade, supporting Markusen's hypothesis: the higher the income, the greater the likelihood of intra-industry trade.

As national income grew, imports of high-valued products increased, while imports of bulk farm products decreased. This phenomenon was especially apparent for Japan (in 1982 and 1990, compared with 1977) and Korea (in 1990, compared with 1977 and 1982). The most notable exception to the pattern of endowment-based trade is the case of the former USSR. The former USSR also has a large land endowment like the United States, but nearly all of the USSR's agricultural commodity imports from the United States are land-intensive commodities, such as food grains, feed grains, or oil crops. These USSR imports from the United States collectively represent 94 percent of total USSR trade from the United States in 1977 and 97 percent in 1982. These USSR imports reflect that nation's poor harvests, chronic supply shortfalls, improper or absent price signals, and political and economic policies that strongly distort the pattern of trade.

Table 9--Grubel-Lloyd measures 1/ of intra-industry agricultural trade between the United States and the world 2/, 1982 and 1990

Country	1982	1990
World	.43	.61
Canada	.49	.63
Mexico	.45	.53
Western Europe	.66	.89
South Korea	.54	.54
USSR	.30	.40
Africa	.72	.43

1/ Grubel-Lloyd measures are calculated as follows:

$$1 - \Sigma_j \frac{| X_j - M_j |}{X_j + M_j}$$

where X_j represents exports in industry j and M_j represents imports in industry j. The coefficients measure relative importance of trade. If exports and imports are equal, the ratio approaches one. When either of the trade components are zero, the measure approaches zero.

2/ These estimates are not exact because Foreign Agricultural Trade of the United States (FATUS), a USDA/ERS periodical and our source of trade data, classifies U.S. imports by type of economy as opposed to by individual countries. Therefore, the figures we used for imports were either totals for developed, centrally planned, or developing economies.

Source: [9].

The overall factor intensity ratio (acres of land per farmworker) of U.S. agricultural exports to the world diminished over time, from 109 in 1977 and 112 in 1982 to 90 in 1990. For Japan, the ratio fell to 74 in 1990 from 102 in 1977; for Korea it was 81 in 1990, down from 112 in 1977.

The growing influence of income levels on trade has an important policy implication: The United States should consider supporting policies that promote the economic growth of some nations importing U.S. agricultural products because of income's considerable effect on trade growth.

Conclusions

This study reveals several implications both for generic support in theoretical explanations of the nature of U.S. agricultural trade and for the economic foundations of U.S. agricultural trade. First, our basic results are consistent with the factor endowment theory of international trade. U.S. agricultural exports are more land-intensive than U.S. agricultural imports. A large proportion of our agricultural trade follows the patterns expected from trade theory and relative-factor endowments. Land-scarce customers, such as Japan, South Korea, and Western Europe, import primarily land-intensive goods, such as feed grains and oil crops (this is changing rapidly as their income grows and domestic policy distorts international trade). Land-abundant Canada, however, imports goods such as fruits, vegetables, and processed foods that are not land-intensive. Thus, this empirical study supports the view that U.S. agriculture has a comparative advantage in producing and trading land-intensive goods rather than labor-intensive commodities.

Second, the land intensity of agricultural exports to Canada, which has land endowments and incomes comparable to those of the United States, was similar to that of U.S. agricultural imports, suggesting that nations with similar resource endowments and/or similar incomes have a high proportion of intra-industry trade.

Third, we noted that the importance of food grains falls as customer incomes rise, while fruits, vegetables, meat products, and other processed foods become more important. This implies that income effects on demand for agricultural products may outweigh forces inherent in the factor endowment trade theory.

With continuing discussion about trade-distorting practices by participants in agricultural trade, sparked by the Uruguay Round of the GATT negotiations, this paper suggests that the land intensity of U.S. agricultural exports, together with its abundant farmland,

provides a logical base for the United States firm stance on free-market competition in world agricultural trade.

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Appendix I: Estimation Procedures

First, we used the 1977 and 1982 U.S. Input-Output (I/O) tables of the U.S. Economy to create a model for factor intensity analysis.[1] This model's usefulness lies in its ability to account for the production of goods and services generated directly and indirectly to meet the final demands of buyers. For example, to produce wheat for export requires the production of fertilizers, pesticides, and fuels. An I/O model facilitates estimating the supporting production required from each industry to produce the agricultural exports in a given year. Using information on harvested acres of land and farm labor used for agricultural production in each industry, one can derive estimates of the factor use required to produce those exports.

To estimate factor intensities, the computational procedure is as follows:

$$R = F [I - A]^{-1} X$$

where:

R is a 2-by-47 matrix of labor and harvested acres required economywide to produce agricultural exports;

[1] Although the years 1977 and 1982 may make the study sound outdated, the benchmark U.S. Input-Output Accounts of the U.S. Economy for 1977 and 1982 have been published in the 1985 and 1991 issues of Survey of Current Business [12, 13].

F is a 2-by-47 matrix of labor and harvested acres per unit of output for each industry;

$[I - A]^{-1}$ is the Leontief inverse matrix of direct and indirect output requirements; and,

X is a 47-by-47 diagonal matrix of agricultural exports.

Second, using the Grubel-Lloyd [3] formula, we estimate intra-industry agricultural trade:

$$T_j = 1 - \{ (|X_j - M_j|)/ X_j + M_j \}$$

where:

T_j is the Grubel-Lloyd measure of intra-industry trade for industry J;

X_j is the nation's exports in industry J;

and M_j is the country's imports in industry J.

If $T_j = 1$, intra-industry trade reaches its maximum (because exports and imports are equal when $T_j = 1$), and minimum when T_j = zero.

Appendix II: Sectoral Breakdown

The Bureau of Economic Analysis issues trade data categorized in 537 commodity sectors. For our analysis, we aggregate the more detailed trade data into 47 sectors. This sectoral breakdown is as follows:

1. Dairy Farm Products
2. Poultry and Eggs
3. Meat Animals
4. Miscellaneous Livestock
5. Cotton
6. Food Grains
7. Feed Grains
8. Grass Seeds
9. Tobacco
10. Fruits
11. Tree Nuts
12. Vegetables
13. Sugar Crops
14. Miscellaneous Crops
15. Oil-Bearing Crops
16. Forest, Greenhouse, and Nursery Products
17. Meat Products
18. Dairy Plants
19. Canning, Freezing, and Dehydrating (excluding fish)
20. Feed and Flour Milling
21. Prepared Feeds (not elsewhere classified)
22. Sugar
23. Fats and Oil Mills
24. Confectionery, Bakery Products, and Macaroni
25. Beverages and Flavorings
26. Miscellaneous Food Processing
27. Fertilizers
28. Agricultural Chemicals
29. Petroleum Refining and Related Products
30. Tobacco Manufacturing
31. Textiles, Apparel, and Fabrics
32. Leather and Leather Products
33. Crude Petroleum and Natural Gas
34. Coal Mining
35. Forestry, Fishing, and Other Mining
36. Other Manufacturing
37. Transportation and Warehousing
38. Wholesale and Retail Trade
39. Eating and Drinking Places
40. Other Non-Commodities
41. Agriculture, Forestry, and Fishery Services
42. Electric Services
43. Gas Production and Distribution
44. Real Estate
45. Special Industries
46. Noncomparable Imports
47. Scrap

Appendix III: Data Sources

Agricultural trade data are taken from published Department of Agriculture (USDA) trade statistics [9, 10, 11]. The USDA defines agricultural commodities as nonmarine food products and farm products that have not gone through complex manufacturing processes. This definition includes commodities, such as raw hides and skins, fats and oils, beer, and wine in addition to the raw commodities usually thought of as agricultural, such as fruits, grains, and natural fibers. This definition, however, does not include manufactured products, such as textiles, forestry products, cigarettes, and distilled alcoholic beverages. The export data include domestic and foreign commodities that were modified in the United States.

Labor coefficients for each industry measure the number of workers per million dollars of output in 1977 and 1982. We derived the coefficients using employment data from the Bureau of Labor Statistics, United States Department of Labor [14]. To incorporate changes in labor productivity from 1982 to 1990, indexes of output per worker in each industry are used to adjust the estimates of required labor use.

Employment estimates include wage and salary workers as well as unpaid family workers, an employment category important in farming.

Similarly, we developed land coefficients that measure harvested acres per unit of crop output in 1977 and 1982 using acreage data from Agricultural Statistics [11]. Yield data from USDA [11] were used to adjust estimates of required acreage to meet exports for 1990 to account for differences in crop yields since the base year 1982.

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